P-2.4 Interpret the resulting motion of objects by applying Newton's three laws of motion: inertia; the relationship among net force, mass, and acceleration (using F = ma); and action and reaction forces.

Revised Taxonomy Levels **2.1 B Represent (interpret) conceptual knowledge**
3.2 B Use (implement) conceptual knowledge
3.2 C_A Use (implement) procedural knowledge

Key Concepts

In Physical Science, students explain the motion of objects on the basis of Newton's three laws of motion: inertia; the relationship among force, mass, and acceleration; and action and reaction forces.

- Newton's First Law of Motion
  - Students are introduced to the concept of inertia,
    - Students are introduced to the Newton as the metric system unit for force
    - Students explain the relationship between mass of an object and its inertia,
    - Students describe the motion of familiar moving objects in terms of inertia
  - Students identify the net forces acting on familiar objects that are accelerating (slowing down, speeding up, or changing direction)
- Newton's Second Law of Motion
  - Students explored the relationship between the motion of an object, it mass, and the force exerted on it, in both sixth and eighth grades, however the concept of acceleration is first introduced in physical science.
    - The concept of net force is addressed in terms of an applied force and an opposing force (friction), or in terms of two applied forces in the same direction. Students identify each force from a story problem and solve for the net force. (In terms of forces applied in the same direction or in opposite directions, no vector problems).
    - Students are introduced to the equation $F_{net} = ma$
    - Students derive the Newton in terms of kgm/sec^2
    - The second Law equation is applied to the weight and mass of objects in terms of the acceleration on gravity ($F_w = ma_g$)
    - Students solve single-step word problems for any of the three variables (F_{net}, m, or a)
- Newton's Third Law of Motion
  - The emphasis in physical science is that the two forces discussed in this law do not cancel because they are not both exerted on the same object.
  - Students analyze and explain the motion of familiar objects (such as a swimmer moving forward by pushing the water backwards) in terms of all three laws.
  - Newton's Law of Universal Gravitation is addressed conceptually as an application of third law
    - Students are introduced to the idea that objects with larger masses exert more force, and objects that are closer together exert more force.
    - Students are introduced to the idea that the law applies to all objects, not just large objects like the earth.

As Physics for the Technology classes and traditional college prep classes will have different curricula based on the choices that are made for standards six through ten, the scope of the core curriculum should vary as well. The emphasis of topics within the core standards will depend on subsequent topics to be addressed.

It is essential for all physics students to

- Interpret and apply Newton's First Law of Motion
- Assess, measure, and calculate the relationship among the force acting on a body, the mass of the body, and the nature of the acceleration produced (Newton's Second Law of Motion)
  - Multi-step problems should be included and may involve combinations of
    - Calculating acceleration from distance, velocity, and time data
    - Determining a net force from vector addition of two forces
    - Determining the mass of an object from its weight
- Interpret and apply Newton's Third Law of Motion
  - Students should identify action-reaction force pairs from diagrams or word problems
  - Students should describe the motion of familiar objects in terms of Newton's Third Law
  - Students should understand gravitation in terms of action reaction forces. If the earth exerts a force on an object the object exerts a force on the earth.
  - Students should apply the third law to solve word problems involving the force exerted on an object.

Physics for the technology differentiation

- Understand that pressured is force per unit of area ($P = F/A$)
  - Understand that the unit for pressure is the Pascal
    - One Pascal is equal to one Newton/meter-squared (N/m^2)
  - compare the pressure of objects with the same weight but in different orientations (an upright book on a table vs. the same book lying flat)
  - Solve problems involving force pressure and area

College prep differentiation

- Assess, and calculate the nature and magnitude of gravitational forces
  - Apply concepts to analyze the motion of satellites
- Understand an "inverse square law" and use the understanding to predict the new value of the masses, force, or distance when one or more of the values is changed.

Assessment

The verb for this indicator is interpret (represent) the major focus of assessment will be for students to "change from one form of representation to another", in this case, the motion of an object can be represented in three forms: verbal description, organized data, and graphical representation. When information about the motion of an object is given in any of the above three forms, students should be able to represent the motion of that object in the other two forms. As this indicator is classified as conceptual knowledge, it is vital that students can apply their knowledge of graphical analysis of motion to any novel set of data, verbal description, or graphical analysis of motion.

The verb implement (use), means that the other major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". Students will use two types of knowledge

- Procedural knowledge is "knowledge of subject-specific techniques and methods" In this case the procedures for solving problems involving force, mass and acceleration, including vector addition, graphing, and algebraic problem solving. The unfamiliar task is a novel word problem or a set of data. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of each of the laws of motion and an understanding of the effect that they have in combination.
- Conceptual knowledge is "the interrelationships among the basic elements within a larger structure that enable them to function together", in this case, Newton's Laws of Motion. Assessments must show that students can assess the motion of an object based on the influence of all three laws.